GLOBE Program™
Teacher's Guide

Second Edition, 1996

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Source: Jan Smolík, 1996, TEREZA, Association for Environmental Education, Czech Republic

Master List of Science and Thinking Skills

observing

asking questions

hypothesizing

designing...
- experiments
- protocols

identifying...
- patterns
- correlations
- relationships
- interconnections

classifying

estimating

predicting

describing

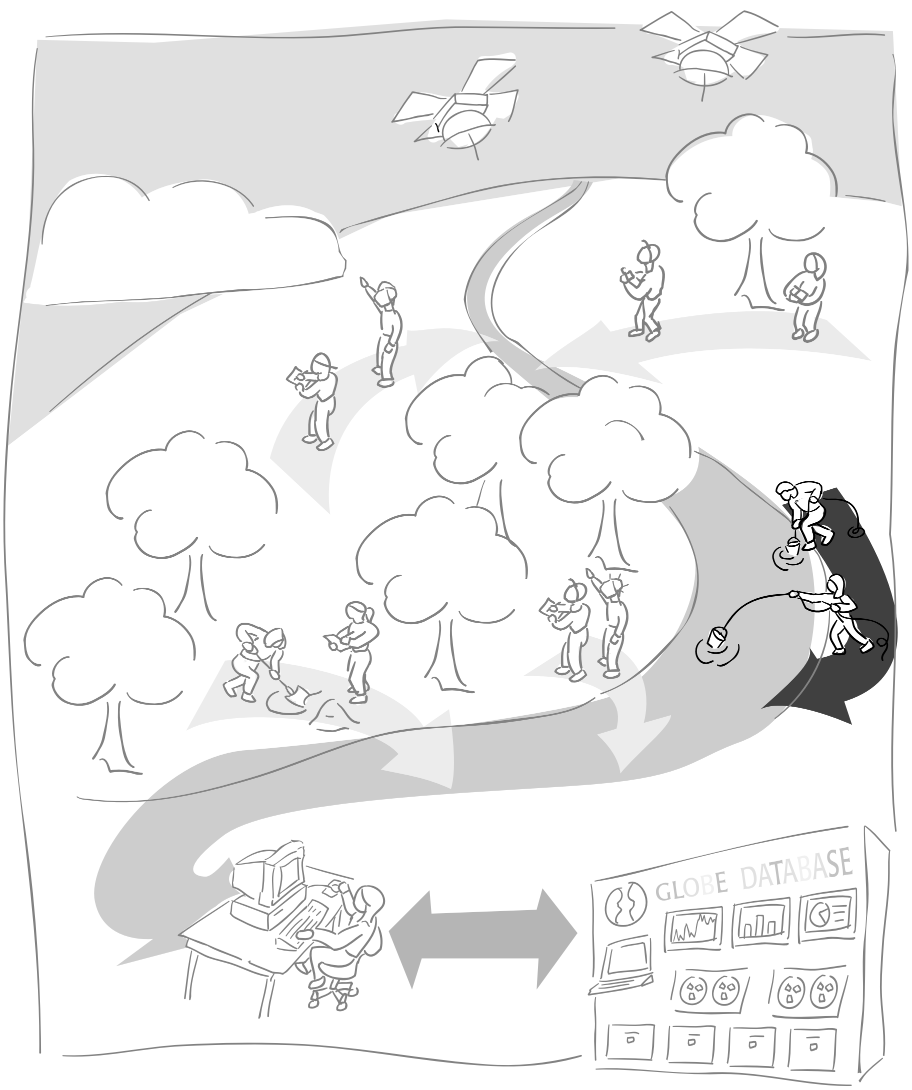
mapping

working with instruments:
- *measuring*
- *calibrating*
- *testing*

working with data:
- *mapping* data
- *graphing* data
- *collecting* data
- *recording* data
- *organizing* data
- *verifying* data
- *analyzing* data
- *summarizing* data

communicating skills:
- *writing* reports
- *communicating* findings
- *communicating* in writing
- *communicating* orally
- *communicating* with graphics

Hydrology Investigation



A GLOBE™ Learning Investigation

Hydrology Investigation at a Glance

Protocols

Monthly Measurements:

Water Temperature
pH
Dissolved Oxygen
Alkalinity
Electrical Conductivity.

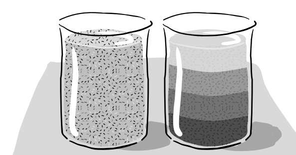
Suggested Sequence of Activities

Read the scientists' letter before you head out into the field.

Water Walk sets the stage for developing interest in water quality/chemistry.

Model Your Watershed provides the big picture view of students' watershed and the water study site in relation to this watershed.

Protocol Practice guides students through learning how to use the instruments and following the protocols so they collect reliable data.



Begin Field Sampling: your class goes to its site and begins the monthly measurements for water.

Focus on Key Science Ideas by performing the following Learning Activities; *Practicing the Protocols, Invisible Passengers*, and *The pH Game*.

What Can Live Here? starts students exploring the connection between water measurements and aquatic life. This activity could be ongoing and revisited regularly as the data accumulates.

Start linking water data to other GLOBE data.

Further Investigations - suggestions for expanding or extending student interests and research.

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Scientists' Letter to Students

Duplicate and distribute to students.

Dear GLOBE Students,

We are the principal scientists on the GLOBE Hydrology and Water Chemistry investigation, and we welcome you to the program. You are participating in a scientific program that addresses a critical gap in our knowledge about the Earth.

Hydrology is the study of water, one of the most critical resources on Earth. Water is essential to all life. You and your fellow students in schools around the world will collect what should be the broadest set of measurements on water quality compiled to date. This GLOBE program will result in more bodies of water being sampled at the same time than ever before. We hope you find this planetary connection exciting, challenging and important.

In measuring the quality of water on your study site, you will learn much about an important part of your local environment and how it changes throughout the year.

We are very interested in your data and are excited about using the data to answer questions about planetary and local hydrology. So please let us hear from you. As the year progresses, you will hear from us with suggestions about how to interpret your data. We hope that together we can find answers to important water-quality questions.

Very truly yours,

Drs. Roger C. Bales & Martha H. Conklin
Professor & Associate Professor
University of Arizona
Tucson, Arizona, U.S.A

Meet Dr. Roger C. Bales & Dr. Martha H. Conklin

Duplicate and distribute to students.

Roger C. Bales and Martha H. Conklin teach and conduct research in hydrology and water resources at the University of Arizona in Tucson, Arizona, U.S.A.

GLOBE: *You are co-principal investigators for GLOBE's Hydrology measurements and you're married to each other?*

Dr. Conklin: Right. We have a two-year old girl and just had a little boy in January.

GLOBE: *You are a husband-and-wife scientific team. How did you meet?*

Dr. Conklin: We met at graduate school. We were both interested in water chemistry.

GLOBE: *Water is H_20. What is your interest in its chemistry?*

Dr. Bales: It's the impurities in water that are of interest and concern.

Dr. Conklin: You won't find pure water in nature because it is a universal solvent. All kinds of materials either dissolve in it or are deposited into it. A purpose of GLOBE is to understand what occurs in water and what happens when substances like chemicals are added to it.

Dr. Bales: According to the head of the U.S. Environmental Protection Agency, about 40% of the surface waters in this country are not fishable and swimmable. Often it's the smaller bodies of water, including many in agricultural areas, that are substandard. You would think that somebody is monitoring their quality, but in most cases, that's not so. Through GLOBE, we'll get information on many more streams, rivers and lakes.

Dr. Conklin: There are many water bodies around the world and each is unique. Students taking measurements is a wonderful way to gather information.

GLOBE: *Why do you need students to collect data? Why not have scientists or graduate students collect it?*

Dr. Bales: We're only a few people. Even if we went to twice as many places, we still wouldn't have much coverage.

GLOBE: *Are you concerned about things that are put in water by natural sources? By human sources? By both?*

Dr. Bales: Both. Impurities—and by impurities I don't mean anything that's necessarily bad, just anything other than H_20—can get in the water because rocks, dust and gases dissolve. Some impurities come from the atmosphere in rainfall or snowfall, which then enter streams and lakes. Some impurities come when humans dump waste into streams or lakes.

GLOBE: *You mentioned the exposure of water to rocks. Do rocks dissolve in water?*

Dr. Conklin: Yes, but very slowly. You can see the long-term-effect in old mountain ranges like the Appalachians. They're weathered and not so high.

Welcome to the Hydrology Investigation

Introducing the Big Picture

We do not just drink water. We *are* water. Water constitutes 50 to 90 percent of the weight of all living organisms. It is one of the most abundant and important substances on the Earth. Water sustains plant and animal life, plays a key role in the formation of weather and helps to shape the surface of the planet through erosion and other processes.

Water continually circulates between the Earth's surface and its atmosphere in what is called the *hydrologic cycle*. The hydrologic cycle, or water cycle, is one of the most basic processes in nature. Reacting to heat from the sun and other influences, water from the oceans, rivers, lakes, soils and vegetation evaporates into the air and becomes water vapor. The water vapor rises into the atmosphere, cools, and turns into liquid water or ice, forming clouds. When the water droplets or ice crystals get large enough, they fall back to the Earth as rain or snow. Once on the ground, water does one of two things. Some water filters into the soil and is absorbed by plants or percolates downward to groundwater reservoirs. The rest runs off into streams and rivers and eventually into the oceans. The surface water evaporates and begins the cycle anew.

The water in a nearby lake, the snow on a distant mountain, the humid air around a tropical island or the drop of morning dew are all part of the same system. The total annual water loss from the surface of the planet equals the Earth's total annual precipitation. Changing any part of the system, such as the amount of vegetation in a region or its land uses, affects the rest of the system.

Despite its abundance, we cannot use most of Earth's water. If we represent the Earth's water as 100 liters, 97 of them would be seawater. Most of the remaining three would be ice. Only about 3 mL out of the whole 100 liters would be water that we can consume.

Water participates in many important chemical reactions and most substances are soluble in water. Due to its capacity as a solvent, truly pure water

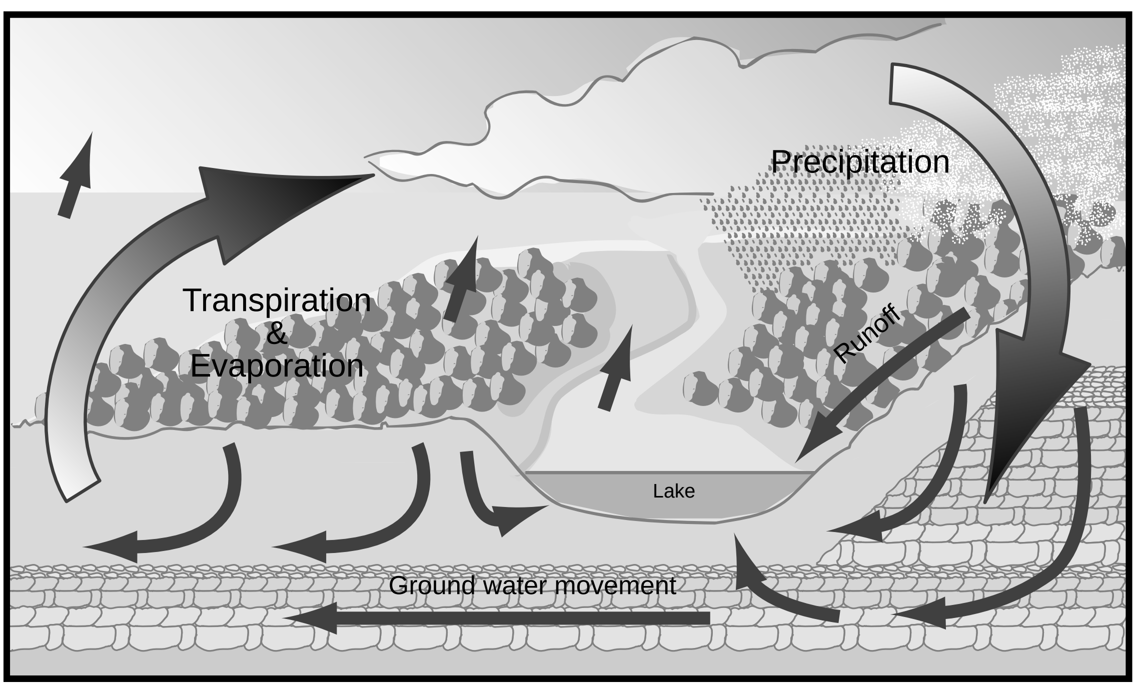
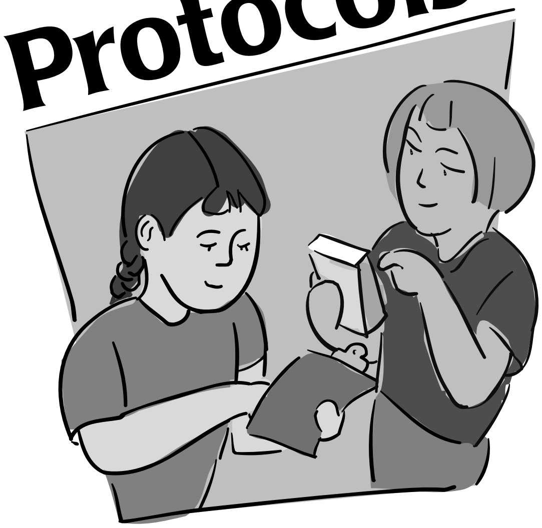


Figure 3-1: Hydrology Cycle

Protocols



Preparing for Your Hydrology Measurements

Collecting the Water Sample

Protocol One: Water Temperature

Immediately after collecting their water sample, students will measure the temperature of the water in the sample.

Protocol Two: Dissolved Oxygen

Students will measure the dissolved oxygen in their water sample.

Protocol Three: pH

Students will measure the pH of their water sample. Method one uses pH indicator paper, and method two uses pH pens or pH meters.

Protocol Four: Alkalinity

Students will measure the alkalinity of their water sample.

Protocol Five: Electrical Conductivity

Students will measure the electrical conductivity of their water sample.

How to Perform Your Hydrology Investigation

Preparing For Your Hydrology Measurements

Selecting the Hydrology Study Site

Ideally, the Hydrology Study Site will be within a watershed that is a prominent feature in the 15 km x 15 km GLOBE Study Site. Within this watershed, select a specific site where the hydrology measurements (water temperature, pH, dissolved oxygen, alkalinity, and electrical conductivity) will be taken. If there is a water body of special interest within your watershed, by all means choose that. Otherwise, the water bodies in order of preference are:

1. Stream or river
2. Lake or reservoir
3. Pond.

An irrigation ditch or other water body may be used if a stream, river, lake, reservoir or pond is not accessible or available within your GLOBE study site.

You should collect all water samples from the same place at the hydrology site each time. This is called the sampling site.

If the site is a moving body of water, like a stream or a river (*lotic*), locate your sampling site at a riffle area (a place where the water is moving but not too fast) as opposed to still water or rapids. If the site is a still body of water, like a lake or reservoir (*lentic*), find a sampling site near the outlet area or along the middle of the water body, but avoid taking samples near an inlet.

Site Description

Once you have selected your hydrology site, be sure to identify the coordinates of this site with the GPS receiver. Enter the location plus other site description information requested on the Hydrology Investigation Site Selection Data Entry Sheet.

Frequency

Collect all water-chemistry measurements at roughly the same time each day, on a monthly basis preferably before 10:00 a.m. local time. However, if your class can do weekly measurements, we encourage you to do so. Your students will be in a better position to see changes due to specific precipitation or runoff events.

If your sampling site freezes over in winter or runs dry, be sure to enter this information on the data sheet each month until you have free-flowing surface water to measure once more.

Note: Certain times of the year provide more exciting measurements. When runoff is occurring on a river, the increased flow and sediment will dramatically change water-chemistry measurements. Just after ice melts off on a lake is also a dramatic time because various layers of water in the lake are mixing with layers near or at the bottom of the lake. Often layers near the bottom end up on top near the surface, thus adding surprising changes to your measurement results. Be observant of seasonal and monthly changes.

Quality Assurance and Quality Control

A quality assurance and quality control (QA/QC) plan is necessary to ensure that test results are as accurate and precise as possible. *Accuracy* refers to how close a measurement is to true value. *Precision* means the ability to obtain consistent results. Reliability in both accuracy and precision is achieved by:

- Collecting the water sample as directed
- Performing tests immediately after collecting the water sample
- Careful calibration, use and maintenance of testing equipment
- Following the specific directions of a protocol exactly as described
- Repeating measurements to check their accuracy and to understand any sources of error

Protocol One: Water Temperature

Purpose

To measure the temperature of the water sample

Overview

The temperature of the water sample is needed for the dissolved oxygen and pH measurements, and for studies of global hydrology questions.

Time

Actual measurement is 5 minutes.

Skill Level

All

Frequency

Monthly, weekly desirable

Key Concepts and Skills

Concepts

Temperature, temperature measurement
Heat, heat transfer, conduction
Accuracy, precision

Skills

Properly using a thermometer
Reading a scale
Recording data

Materials and Tools

Alcohol-filled thermometer
A clock or watch
Enough string to lower the thermometer into the water
Data sheets

Preparation

Bring the tools and materials to the Hydrology Study Site.

Prerequisites

None

What To Do and How To Do It

Before using the thermometer, calibrate it following the instructions in Protocol Five of the Atmosphere Investigation. The measurement takes only a few minutes to complete. The main concern is to allow sufficient time for the thermometer to equilibrate to the temperature of the water – perhaps three to five minutes.

1. Tie one end of a piece of string to the end of the thermometer and the other end to a rubber band. Slip the rubber band around the wrist so that the thermometer is not lost if it is accidentally dropped in the water.
2. Hold the end of the thermometer (opposite the bulb) and shake it several times to remove any air in the enclosed liquid. Note the temperature reading.
3. Immerse the thermometer to a depth of 10 cm in the sample water for several minutes.
4. Remove the thermometer and quickly note the temperature reading. Re-immerse the thermometer for another minute or until it stabilizes. Read it again. If the temperature is unchanged, then proceed to Step 5.
5. Record this temperature along with the date and time on the Hydrology Investigation Data Work Sheet.
6. Take the average of the temperatures measured by the student groups. If all measured values are within 1.0° C of the average, submit the average value to the GLOBE Student Data Server. Otherwise, repeat the measurement.

Water Walk

Students become acquainted with their Hydrology Study Site and profile its characteristics.

Model Your Watershed

Students will combine their own local observations with a topographic map and satellite-derived imagery to construct a three-dimensional model of their watershed.

Practicing the Protocols

In the classroom, students practice using the instruments or kits and protocols, the range of measurements and explore sources of variation and error.

Invisible Passengers

This classroom activity will demonstrate to students that water contains "invisible passengers," substances in the water that affect its characteristics. They will describe a variety of natural and introduced materials that are found in bodies of water, and observe the effects of silt, sand, gravel, salt and odor sources on water.

The pH Game

Students will play a game to better understand the importance of pH levels.

What Can Live Here?

Students compare the hydrology data collected to the range of tolerances for a variety of aquatic organisms.

Further Investigations Using GLOBE Data

Suggestions for examining the relationships between hydrology data and other types of GLOBE data, or hydrology data from other sites.

Water Walk

Purpose

To become familiar with the hydrology of your locale.

Overview

Students will visit the Hydrology Study Site, conduct a visual survey to discover information about local land use and water quality, and document their findings by mapping and profiling the water body. They will use this initial investigation to raise questions about local land use and/or water chemistry issues that may require further study.

Time

Field trip time plus one class period.

Level

All

Key Concepts and Skills

Concepts

- Surface water exists in many forms, such as: ponds, lakes, rivers, and snow cover.
- Water characteristics are closely related to the characteristics of the surrounding land.
- Water moves from one location to another.
- Surface water has many observable characteristics, such as: color, smell, flow, and shape.

Skills

- *Observing* water at the study site.
- *Describing* water at the study site.
- *Organizing* observations.
- *Asking* questions based on observations at the study site.
- *Identifying* relationships between land characteristics and water characteristics.
- *Communicating* initial observations and interpretations orally, in writing and graphically.
- *Mapping* the hydrology of the study site.

Materials and Tools

- Drawing materials and tools for creating pictures and maps
- GLOBE Science Notebooks and pens
- Still or video cameras for photography
- Compass and measuring sticks or twine
- Clear plastic cups or bottles for observing the clarity and color of the water

Preparation

Obtain topographic maps and satellite imagery of your study site.

Prerequisites

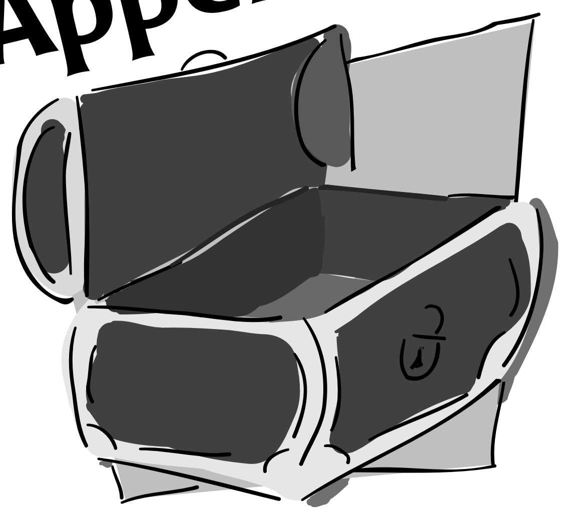
None

Background

Your body of water is part of a watershed. A watershed is the area drained by a river and its tributaries. The topography of the area determines the boundaries and shape of the watershed. The surrounding land and the uses of this land – towns, cities, highways, agricultural, livestock, timber harvesting, natural vegetation, etc., influences the water chemistry of bodies of water within the watershed.

Many factors can affect the characteristics of the water in a river system, lake, or pond. Characteristics of water include: temperature, color, shape, etc. In the protocol, you will be collecting data about water quality as measured by dissolved oxygen, pH, alkalinity and electrical conductivity. Field observations increase the students' ability to conceptualize links between land characteristics and water characteristics. This

Appendix



Surface Water Measurements Data Work Sheet

Contour Line Basics

Glossary

Surface Water Measurements Data Entry Sheet

Hydrology Study Site Data Entry Sheet